



UH-60 Airloads Prediction by Coupled CFD

Airloads Workshop

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February 17th, 2011



Software

- CFD: OVERFLOW2 v2.2b
 - 4th order central differencing in space; 2nd order dual timestepping
 - Spalart-Almaras 1-eq. turbulence model with rotational corrections (inviscid off-body)
 - Blade surfaces modeled as fully-turbulent, viscous, adiabatic walls
- Comprehensive: CAMRADII v4.6
 - CSD: non-linear finite elements
 - Control system, trim
- Delta-coupling technique
 - CAMRADII→OVERFLOW2 = blade sectional motions (elastic deformations plus rigid motions)
 - OVERFLOW2→CAMRADII = blade sectional airload deltas (normal force, chord force, and pitching moment)



CFD Grid

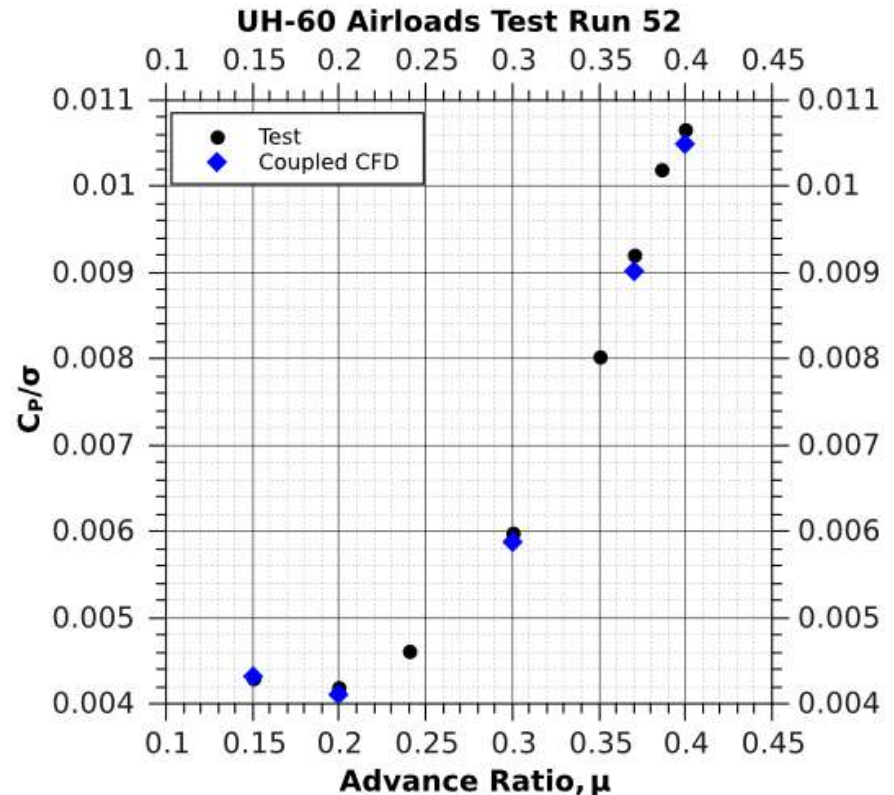
- “Alan Egolf grid”. Rotor only with notional centerbody
- 26.2M points total (10.7 in near-body)
- Blade grid: 157x145 chord/span, $y^+=1$
- Finest off-body spacing was 10% C_{tip}
- Also ran a fine grid with 50.7M points (35.2M near-body) for selected cases.

Grid picture goes here.



Speed Sweep Overview

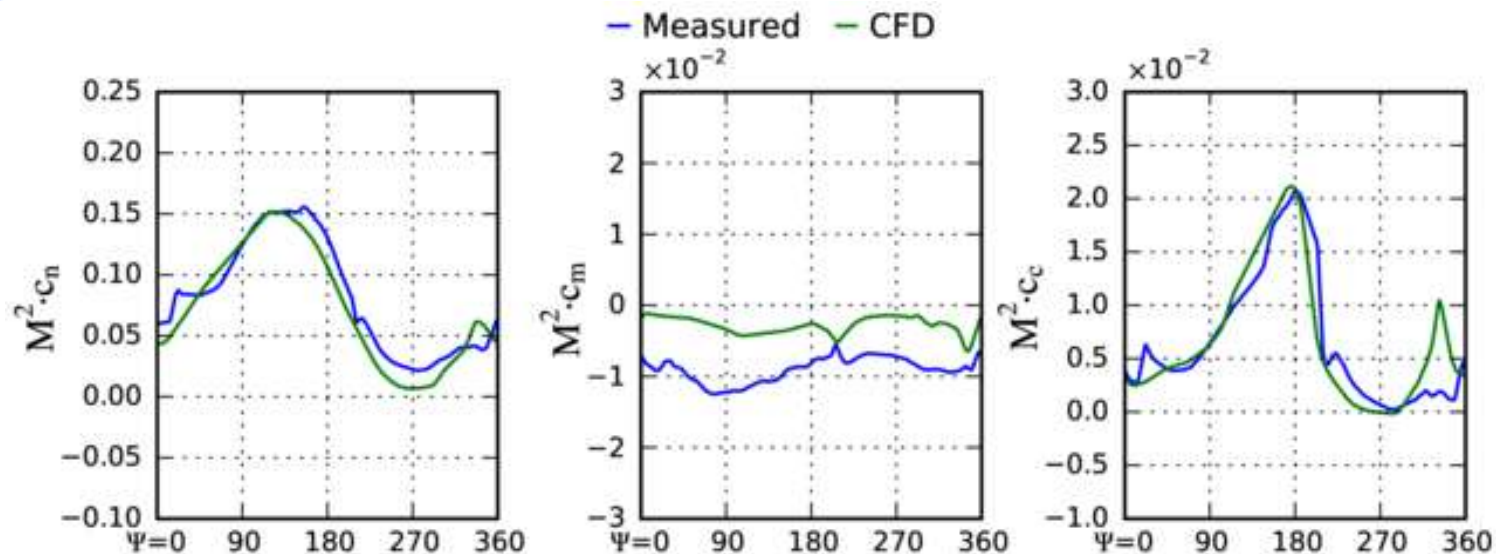
- $M_{\text{tip}}=0.65$
- Tunnel was trimmed to match predicted 1g level flight at various speeds— C_L , C_D , $C_{M,R}$, $C_{M,P}$
- Predictions trimmed to match tunnel loads— C_T , $C_{M,R}$, $C_{M,P}$ —at each speed.



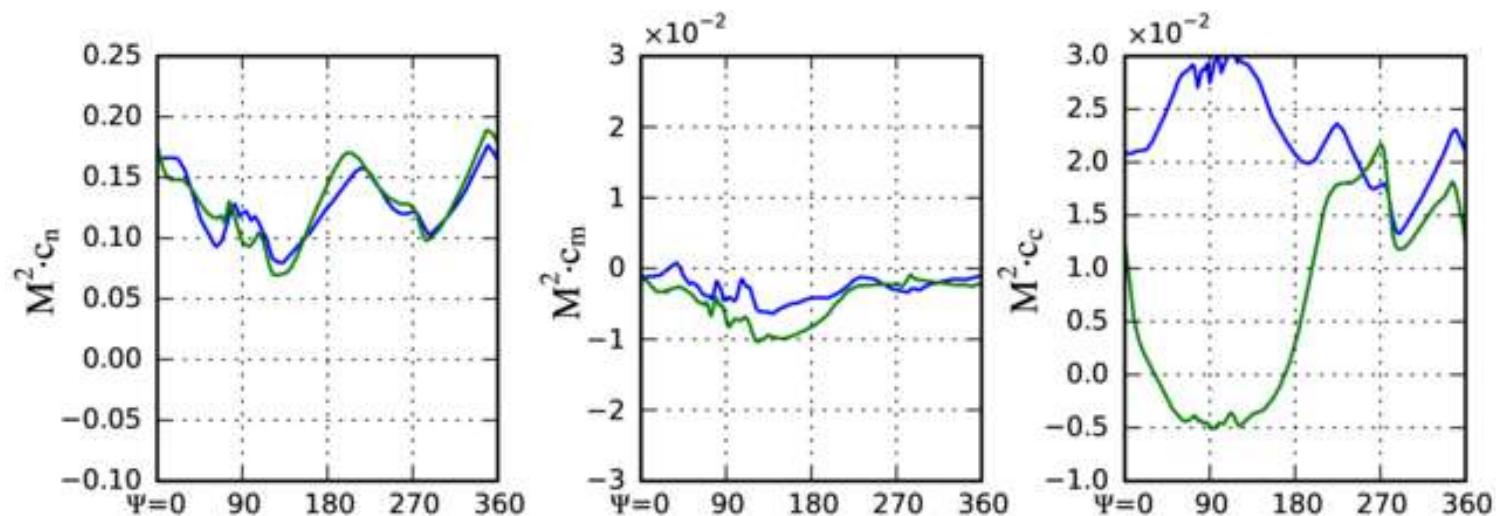


Speed Sweep: $\mu=0.3$

$r/R=0.4$



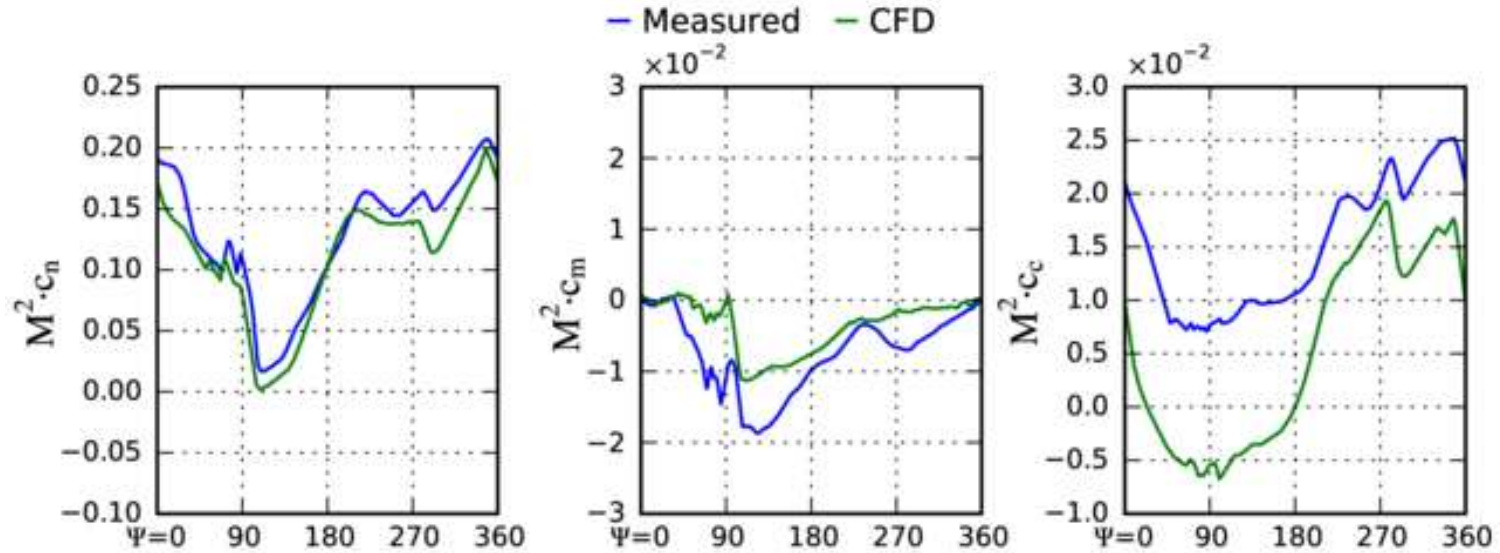
$r/R=0.775$



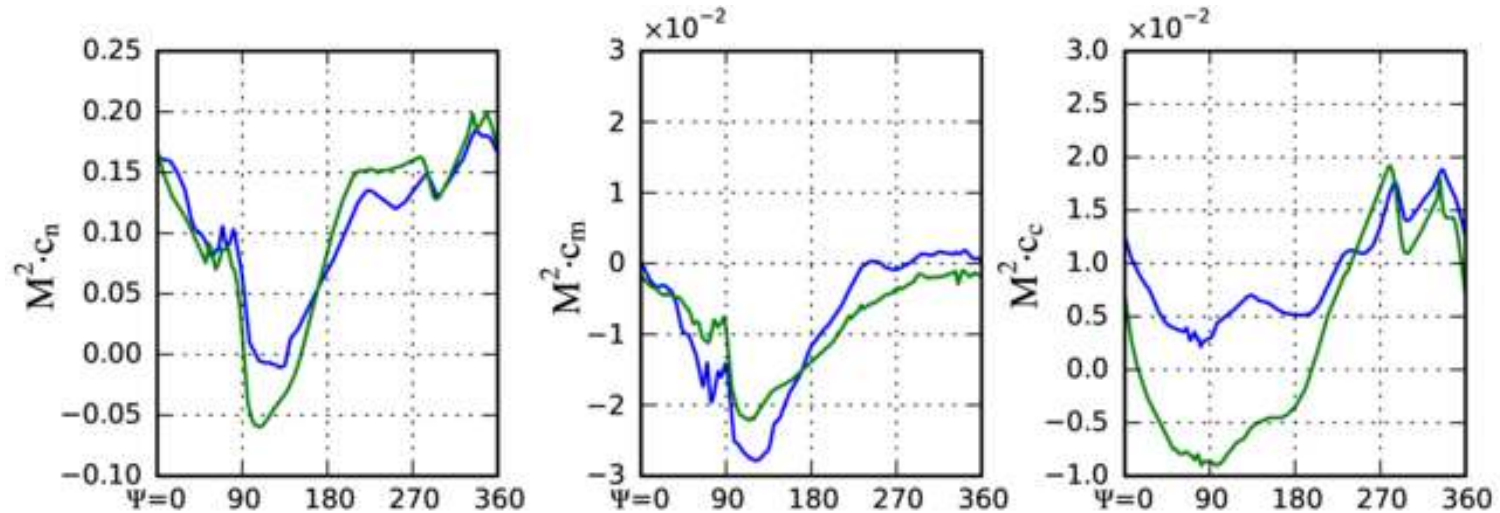


Speed Sweep: $\mu=0.3$

$r/R=0.865$



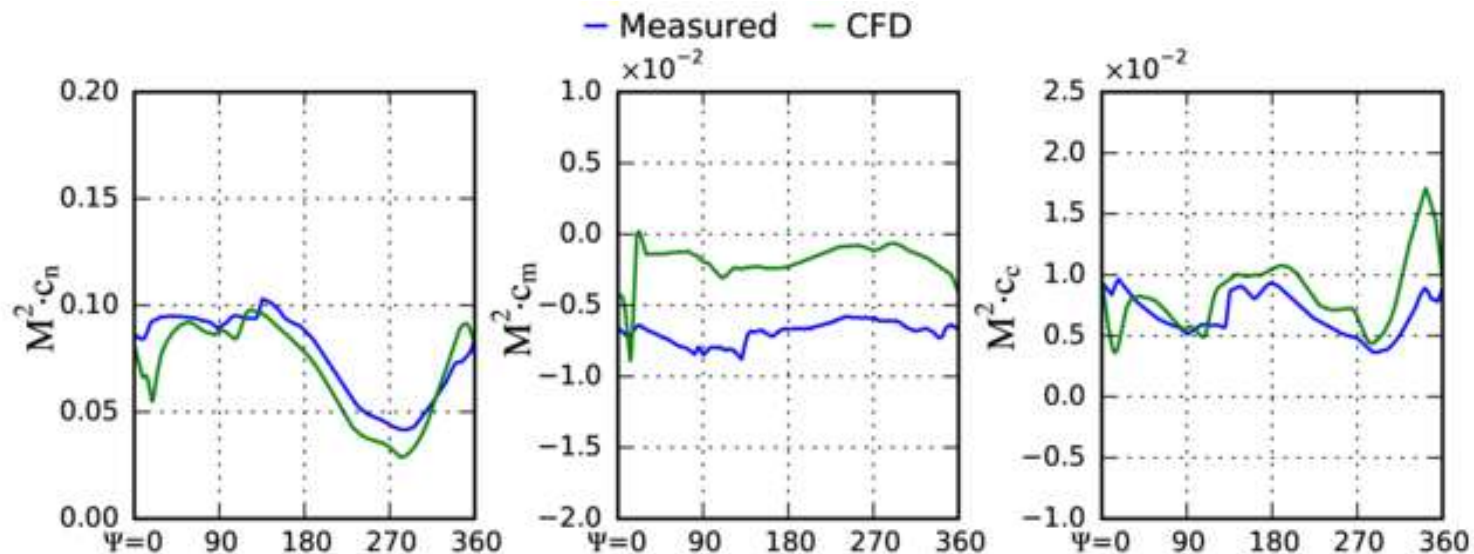
$r/R=0.92$



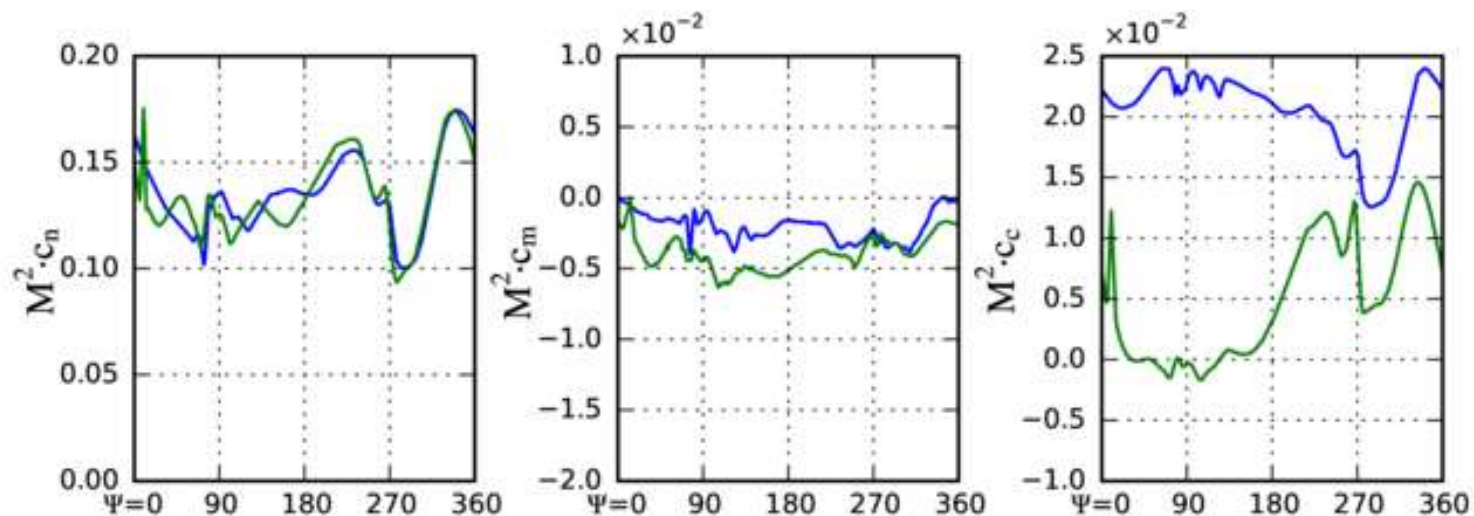


Speed Sweep: $\mu=0.15$

$r/R=0.4$

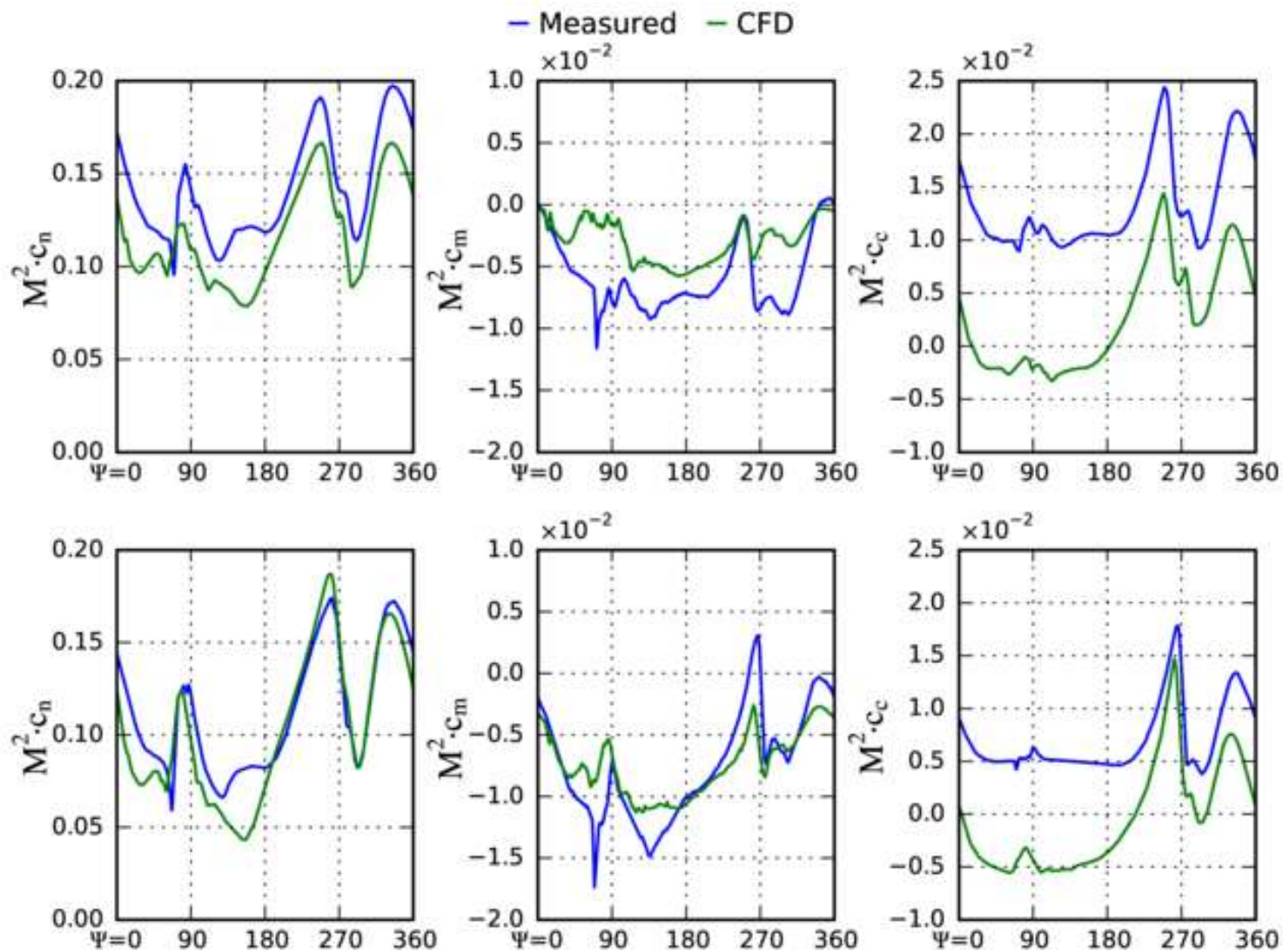


$r/R=0.775$





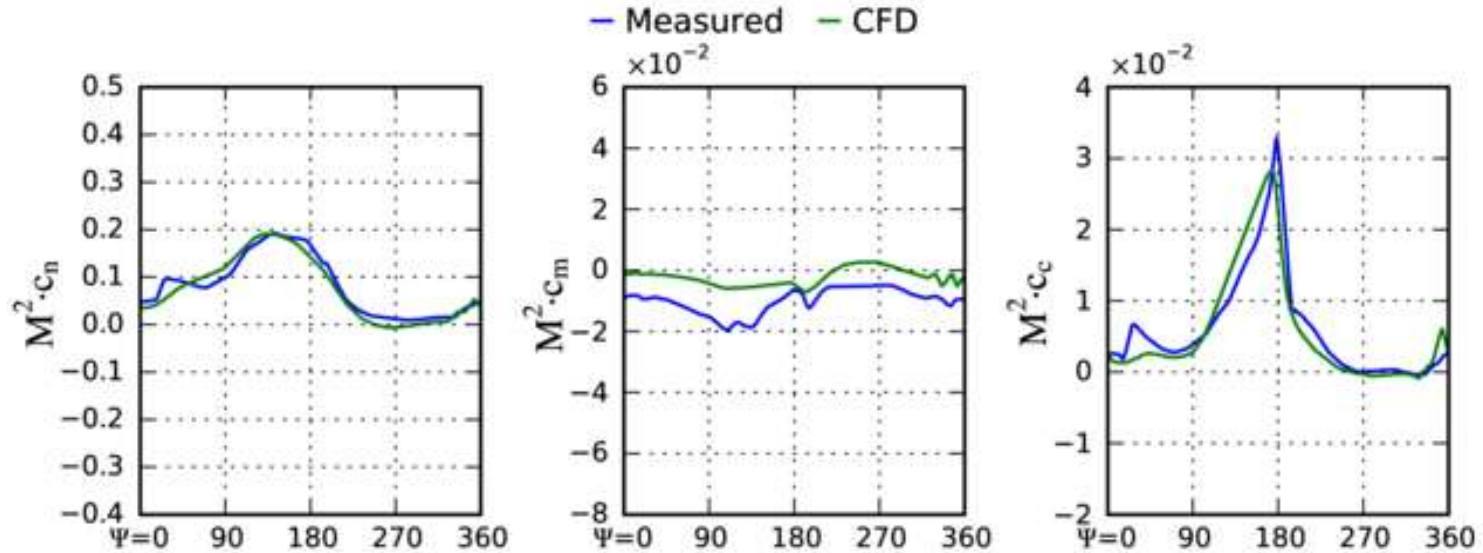
Speed Sweep: $\mu=0.15$



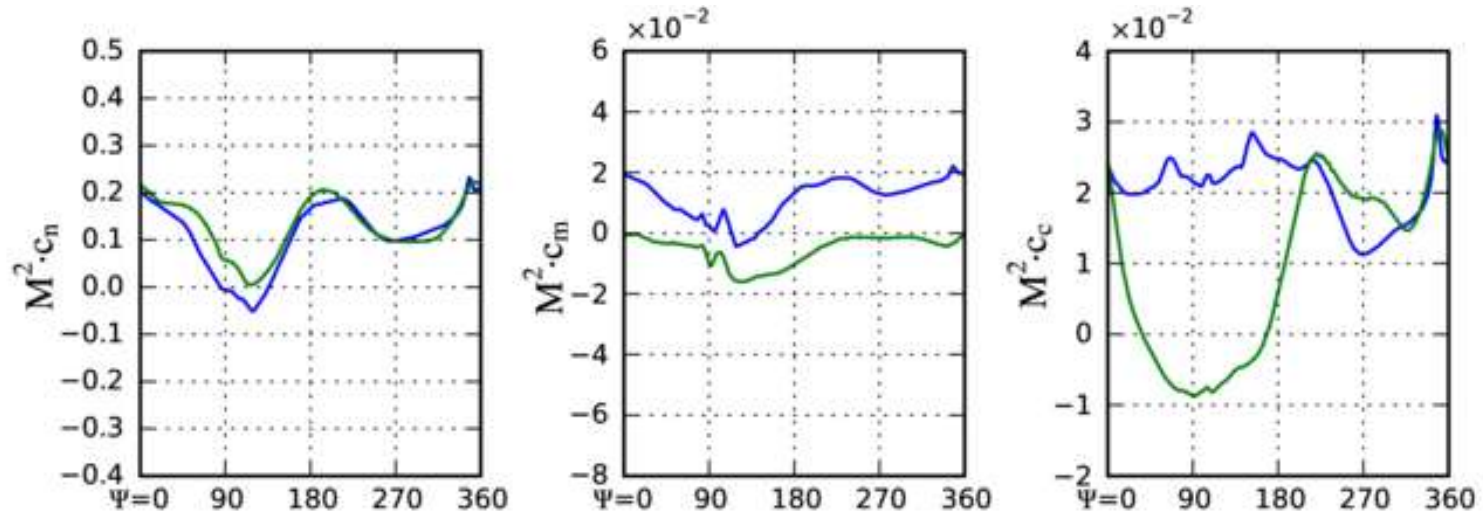


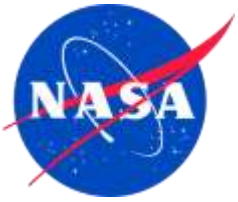
Speed Sweep: $\mu=0.4$

$r/R=0.4$



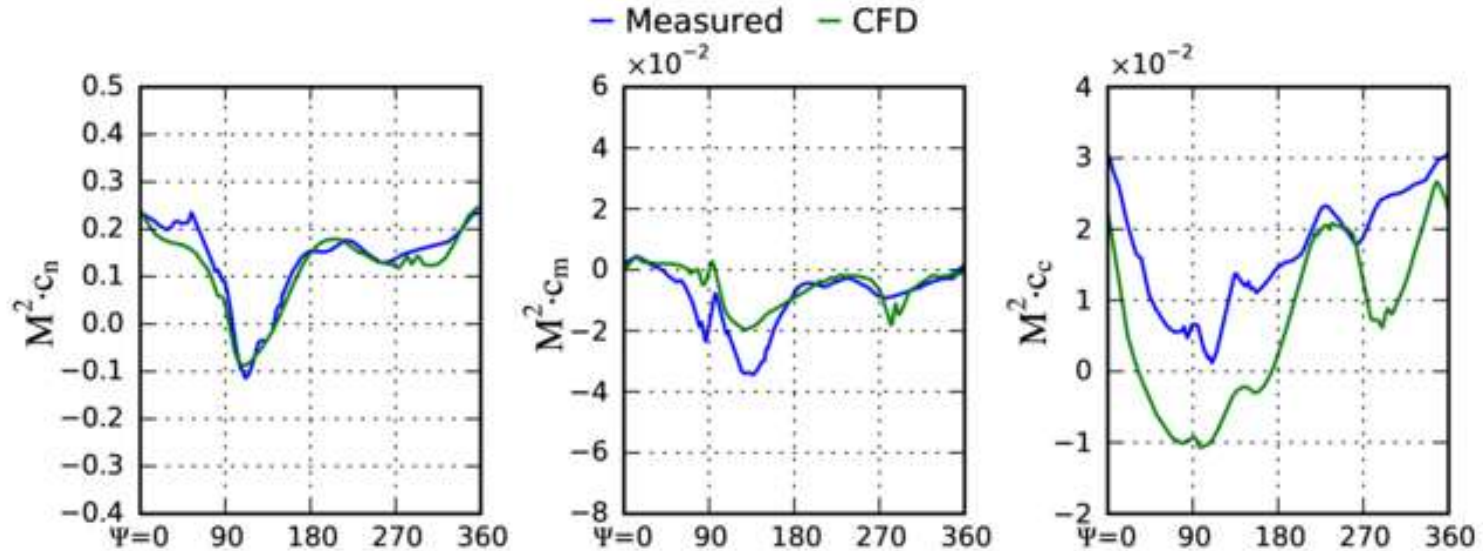
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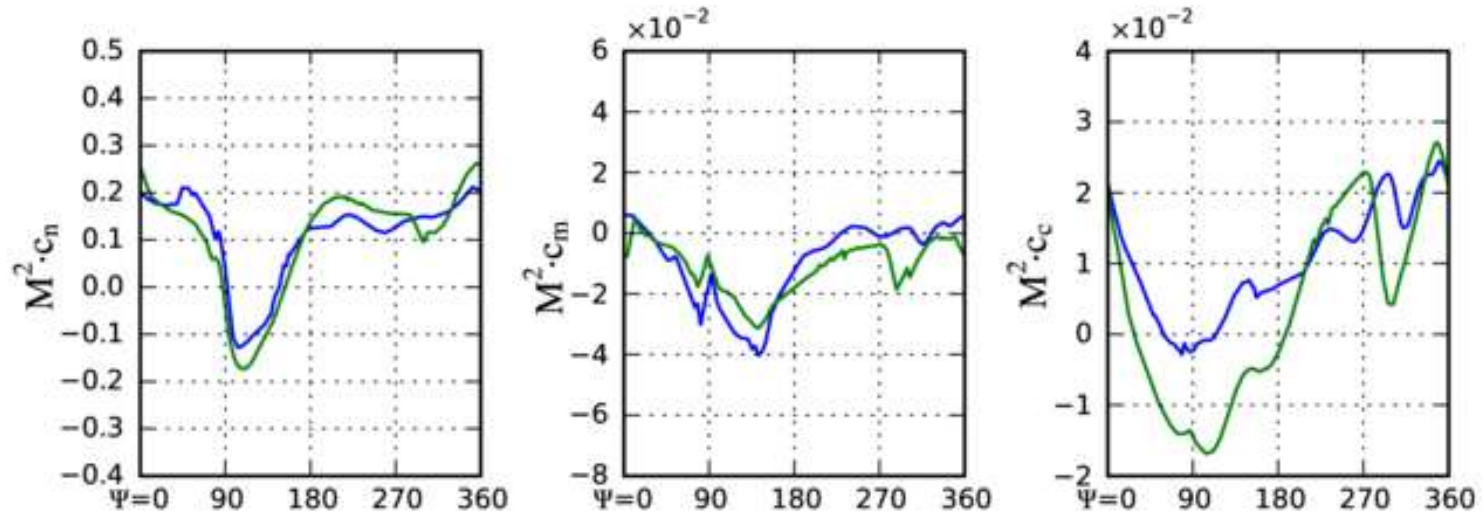


Speed Sweep: $\mu=0.4$

$r/R=0.865$



$r/R=0.92$

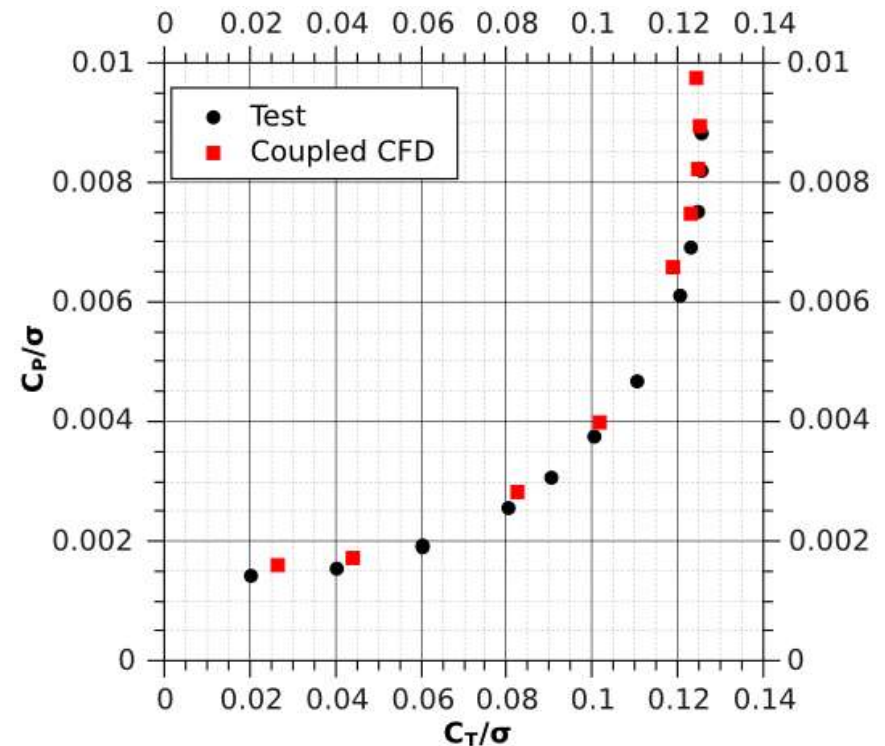
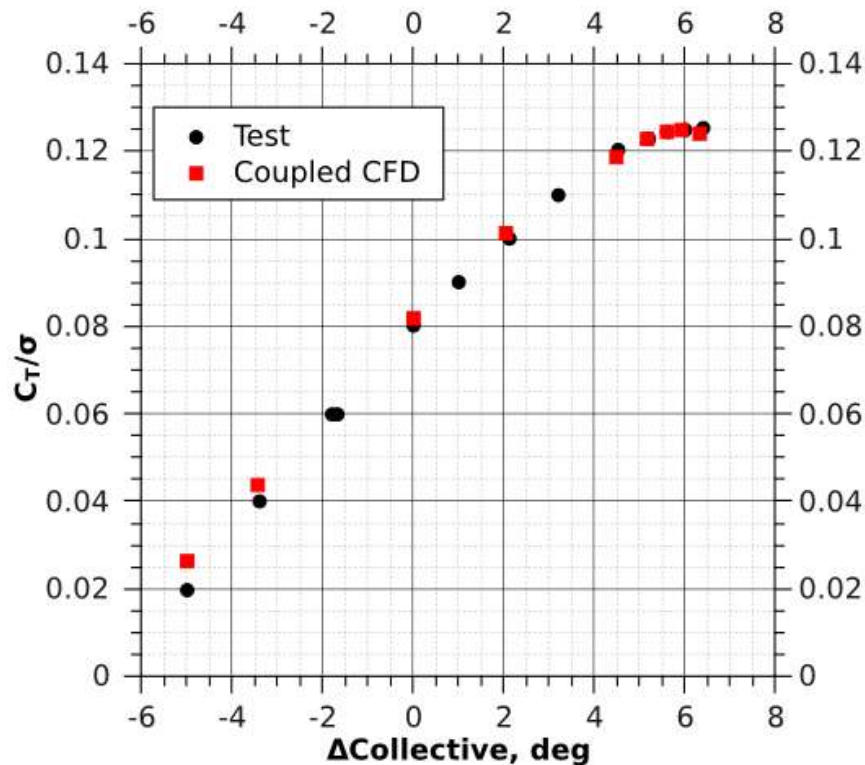




Collective Sweep

- $\mu=0.3$, $M_{tip}=0.625$, $\alpha=0$, no hub moments
- $C_T/\sigma=0.08$ taken as baseline with remaining points set as collective

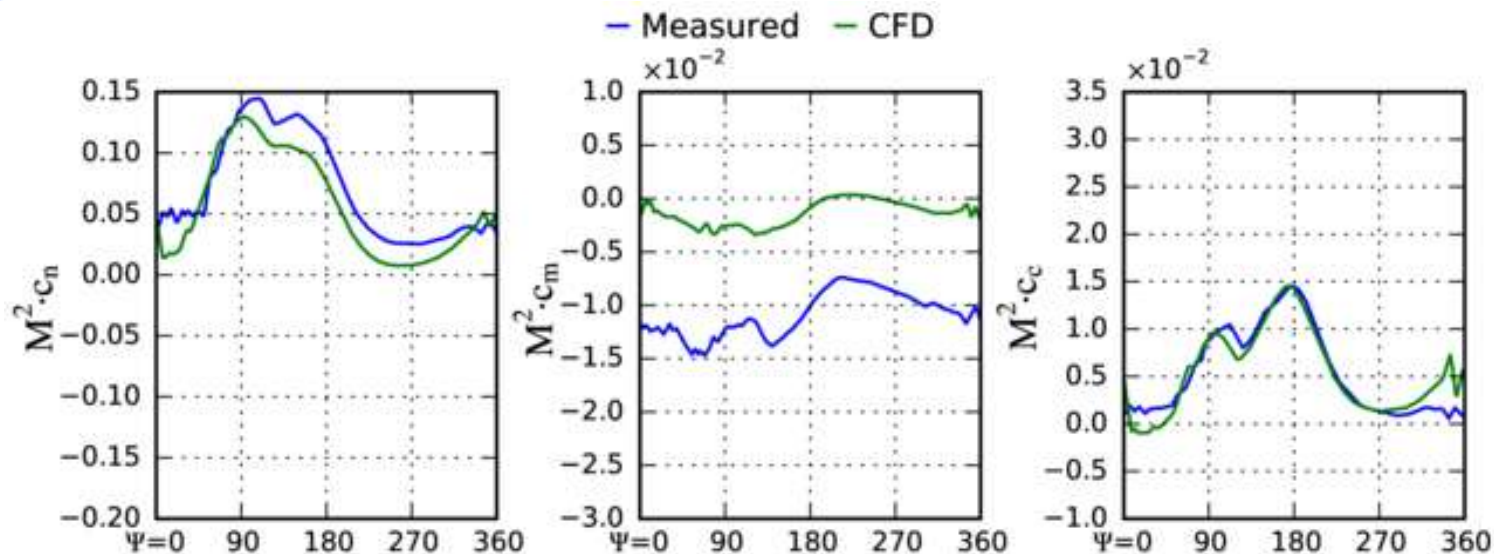
- deltas from the baseline
- Lift curve slope is under predicted by about 7% compared to test



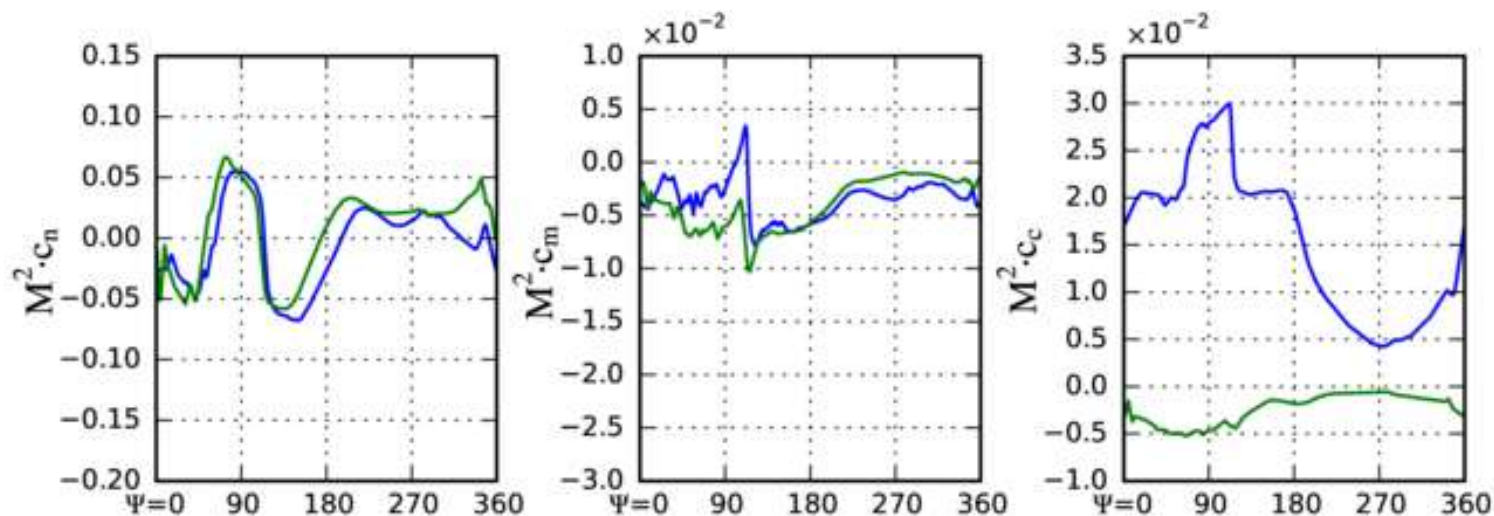


Collective Sweep: -5°

$r/R=0.4$



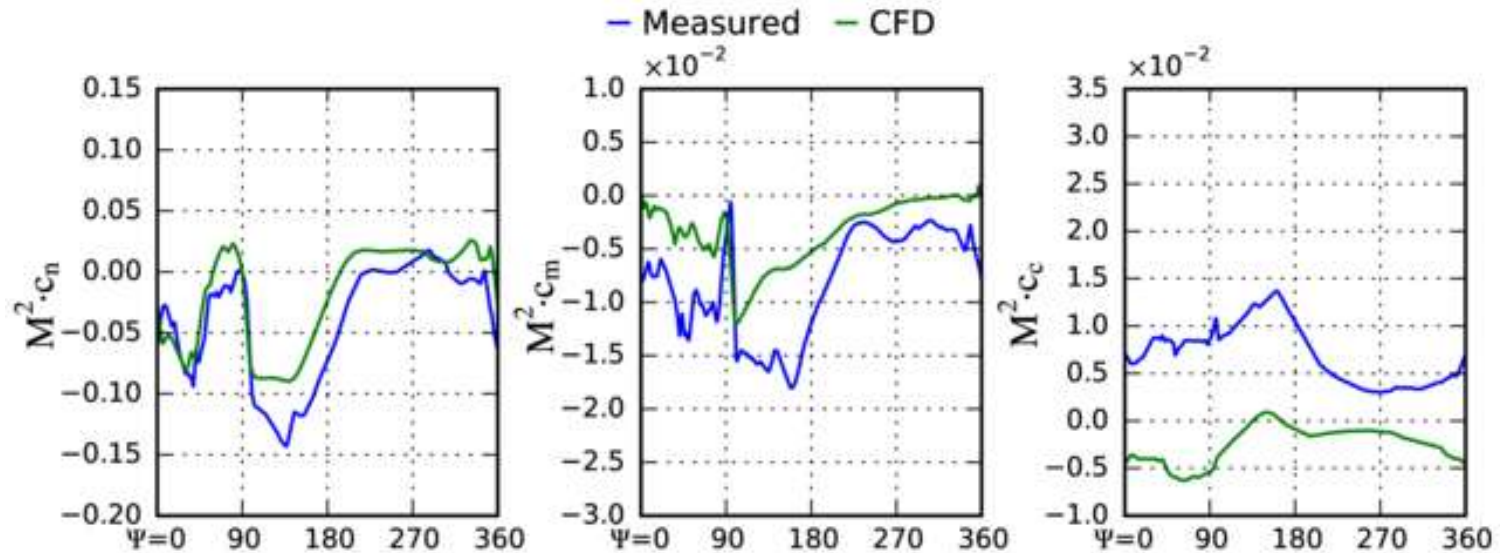
$r/R=0.775$



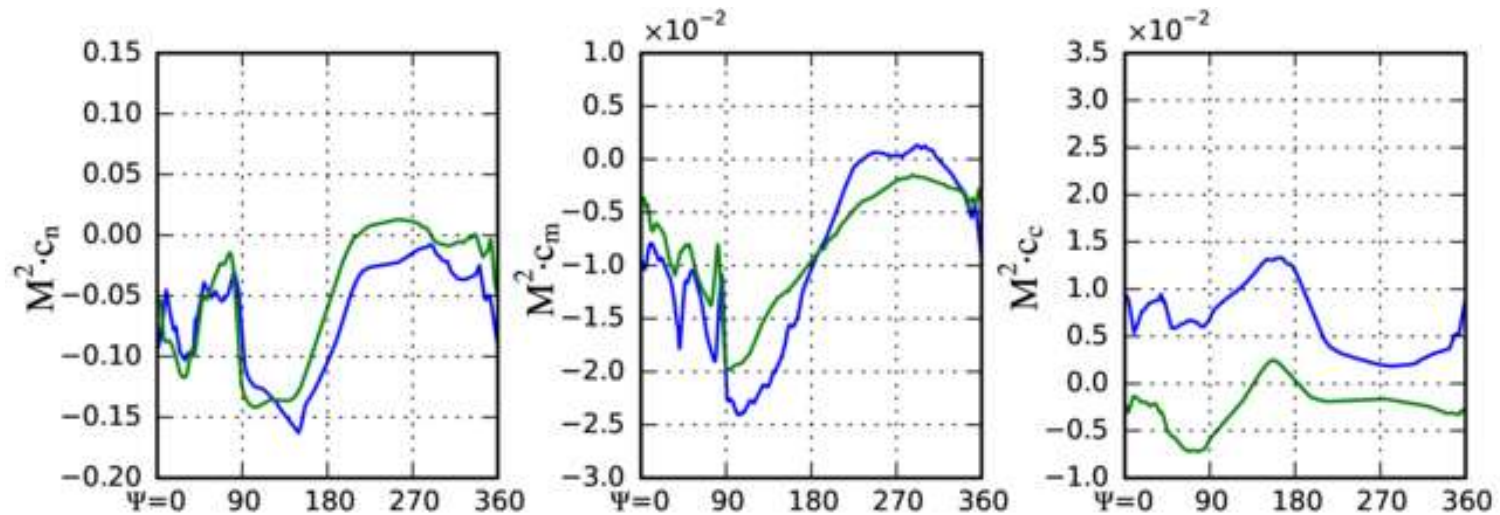


Collective Sweep: -5°

$r/R=0.865$



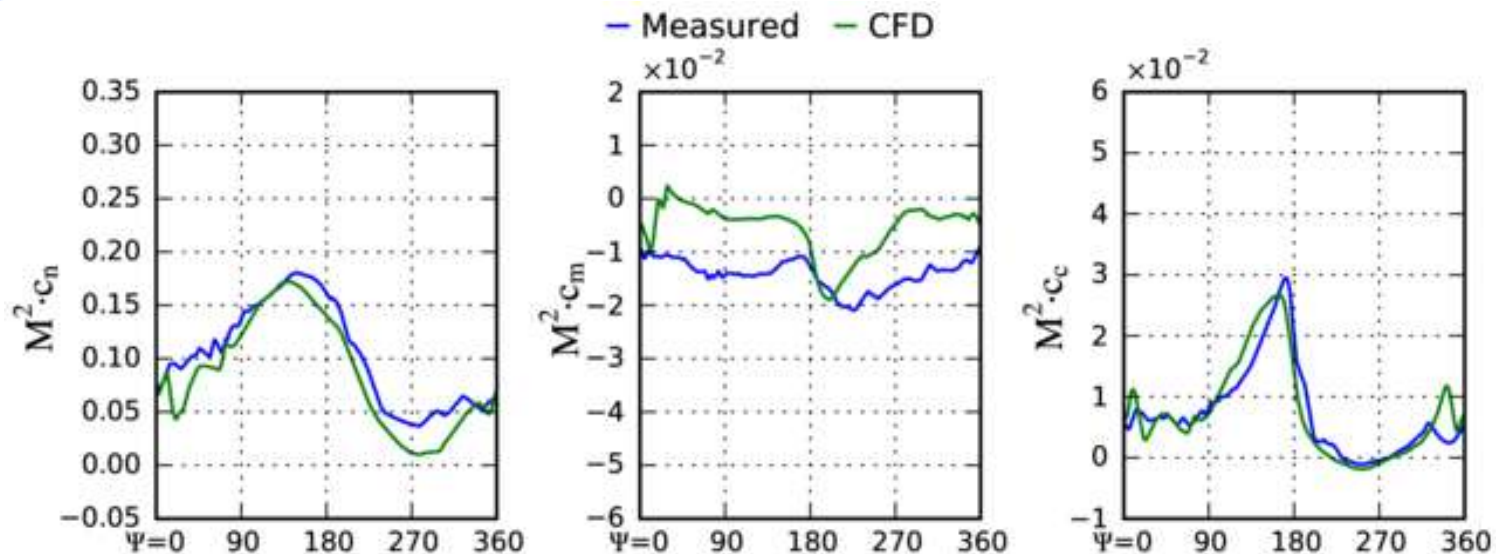
$r/R=0.92$



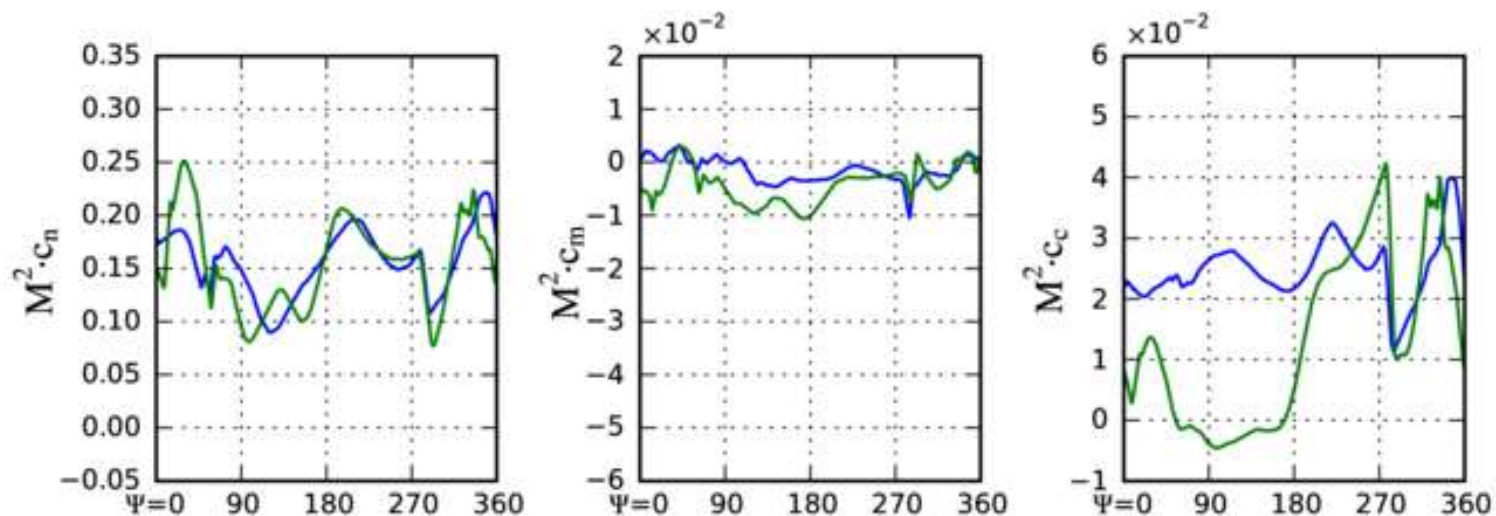


Collective Sweep: +4.5°

$r/R=0.4$



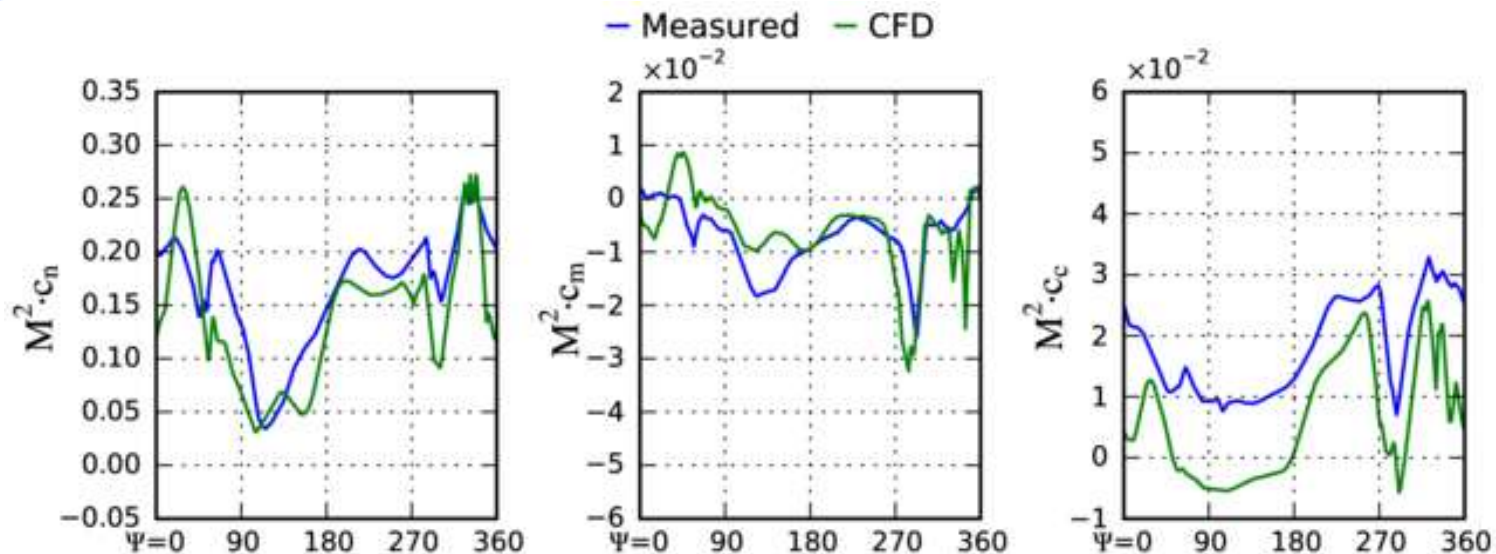
$r/R=0.775$



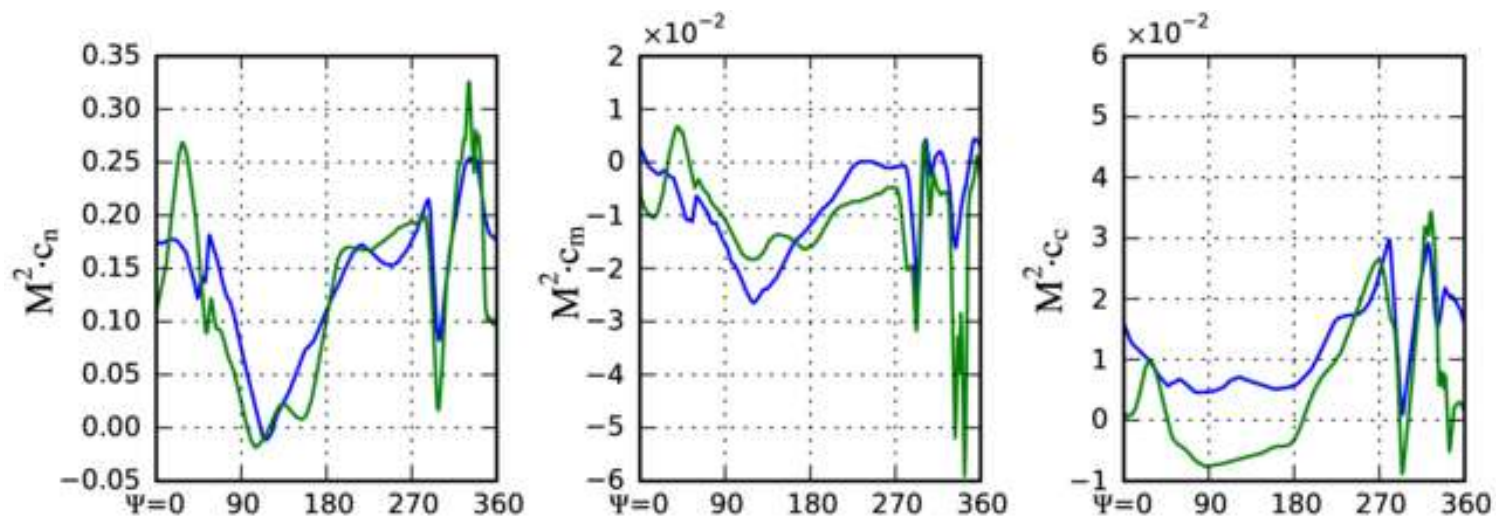


Collective Sweep: +4.5°

$r/R=0.865$



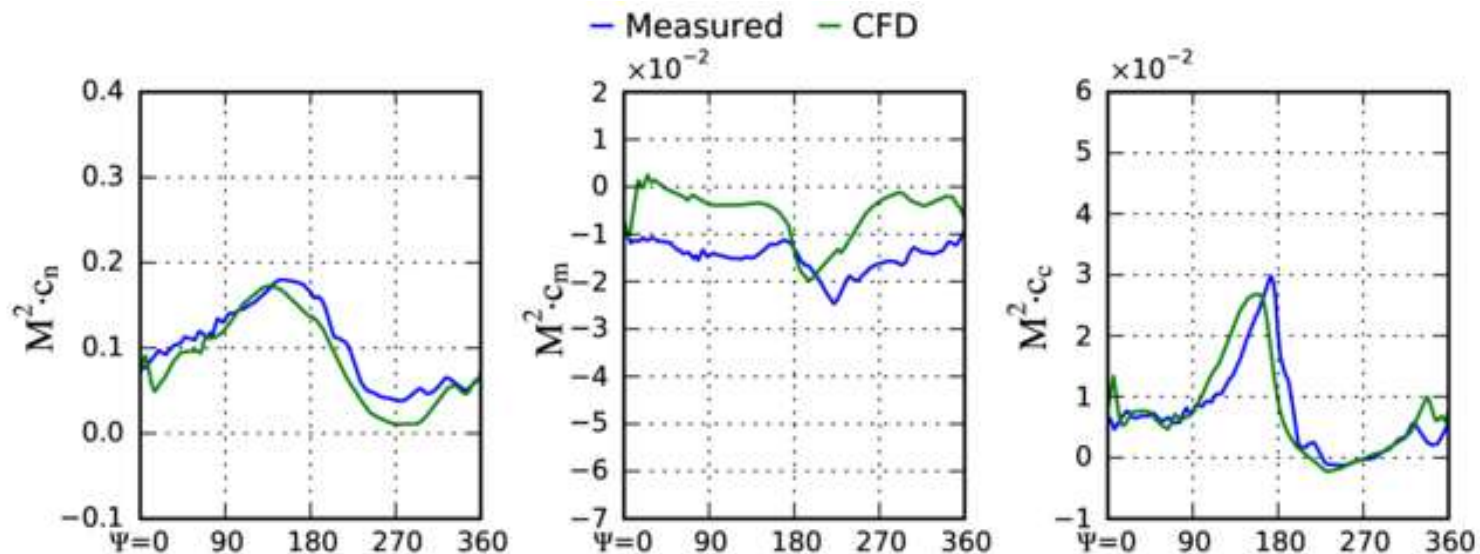
$r/R=0.92$



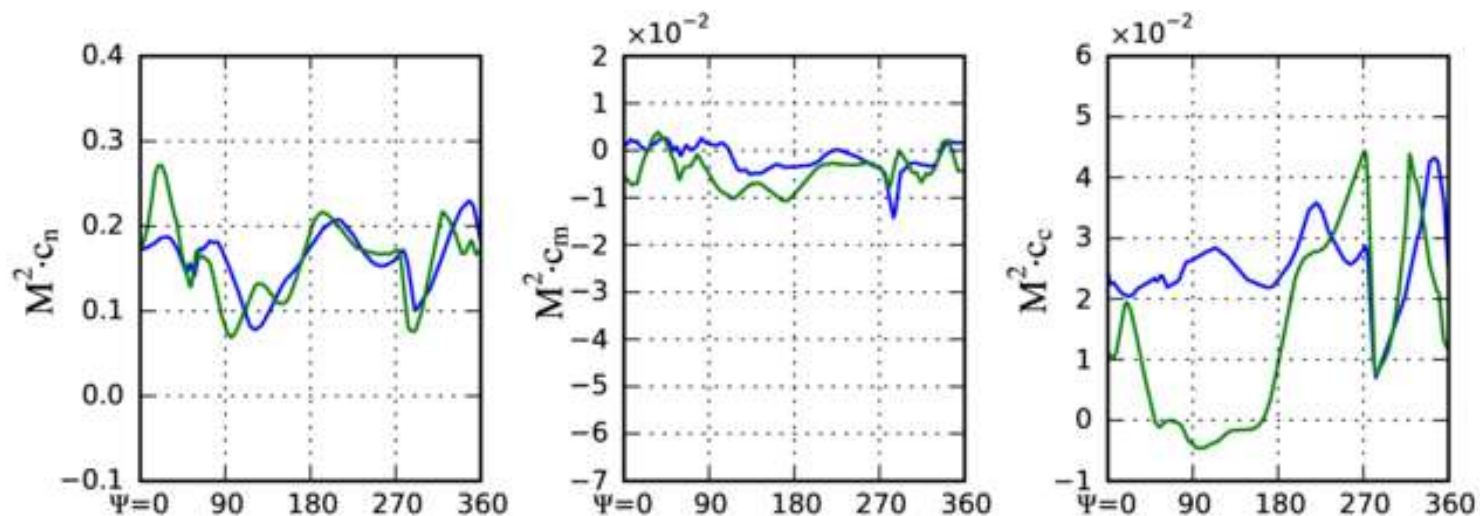


Collective Sweep: +6.5°

$r/R=0.4$



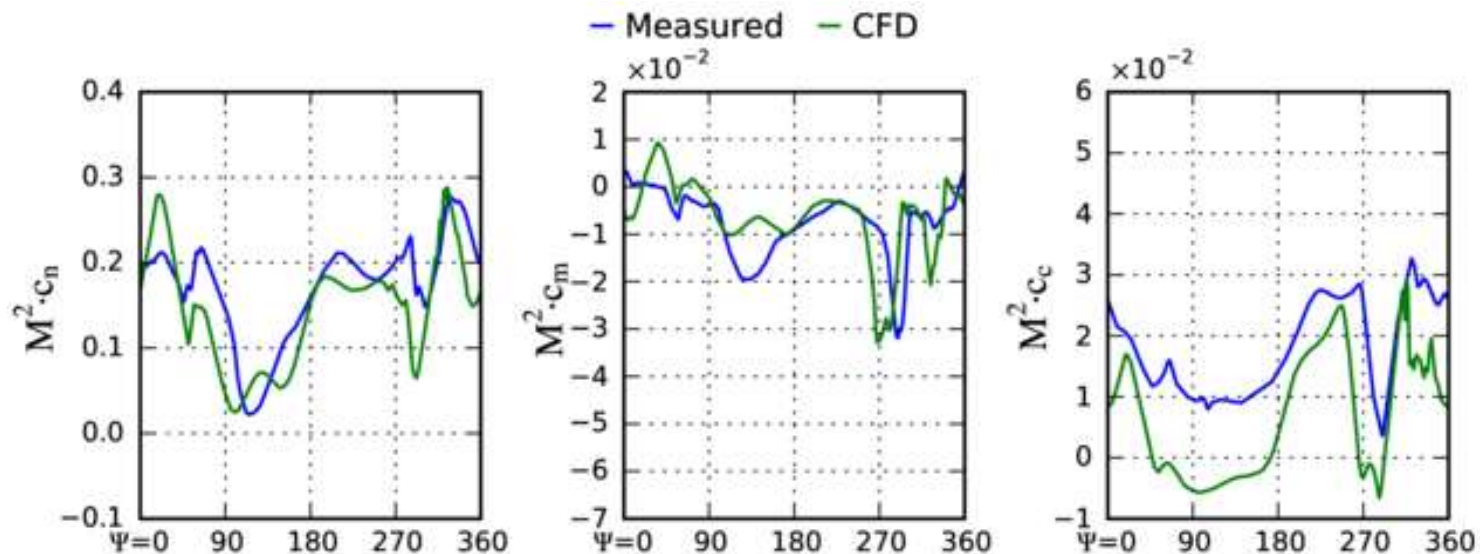
$r/R=0.775$



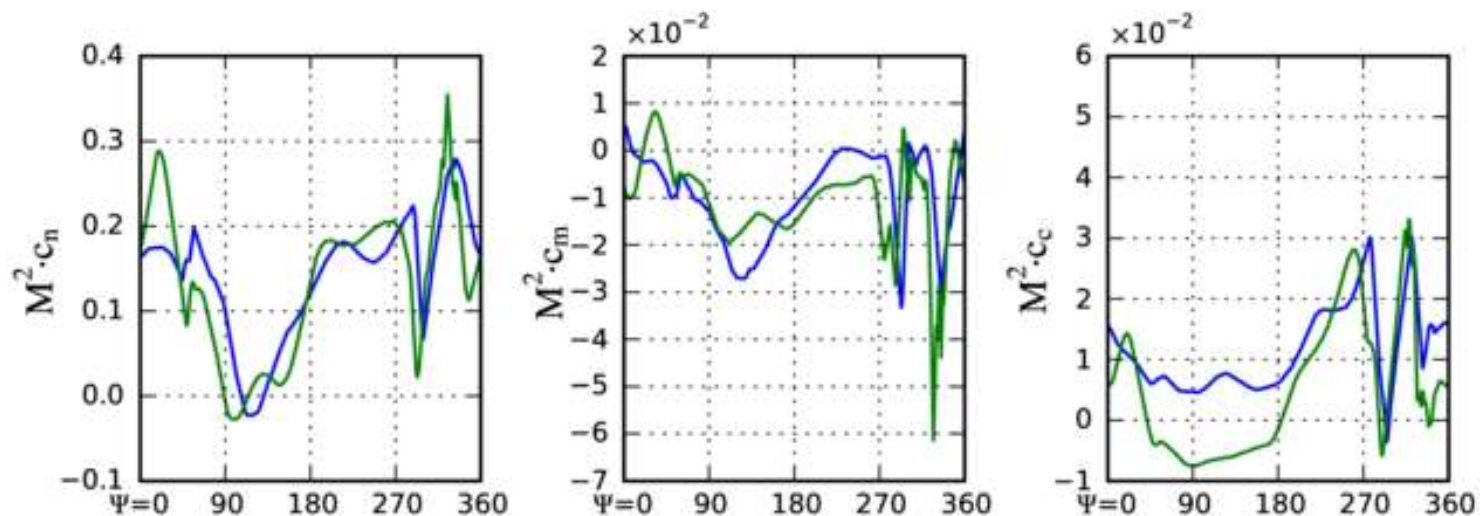


Collective Sweep: +6.5°

$r/R=0.865$



$r/R=0.92$





Lessons Learned

- Modeling trim tab deflection is necessary to get loads right at $r/R=0.775$
- Small errors in qc definition can pollute Comprehensive code's perception of performance (especially power)